HONEYWELL

Technical Manual

INSTRUCTIONS FOR

ACCUDATA 120 DC AMPLIFIER

Honeywell

TEST INSTRUMENTS DIVISION • 4800 EAST DRY CREEK ROAD • DENVER, COLORADO • 80217

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TECHNICAL MANUAL

INSTRUCTIONS

FOR

ACCUDATA 120 DC AMPLIFIER

FEBRUARY, 1967

HONEYWELL - Test Instruments Division - 4800 East Dry Creek Road - Denver, Colorado - 80217
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SECTION I — INTRODUCTION

1-1. PURPOSE

This manual describes installation, operation, and maintenance for the Accudata 120 DC Amplifier.

For optimum performance from the amplifier, acquaint yourself with its features and operating principles before placing the amplifier into operation.

1-2. UNIT DESCRIPTION

The Accudata 120 DC Amplifier, Figure 1-1, is a solid state, direct-coupled, wideband, high gain differential amplifier ideally suited for high speed data acquisition systems. The amplifier design features high impedance input with an output current capability for driving fluid damped galvanometers in reading oscillographs, or driving magnetic tape recording systems. The integrated solid state power supply operates on line frequencies from 50 to 400 Hz and is available for either 115 volt ac or 230 volt ac line voltages. The output of the internal supply (44 VDC) can be used for excitation of bridge type transducers in conjunction with the Accudata 105-3 Gage Control Module.

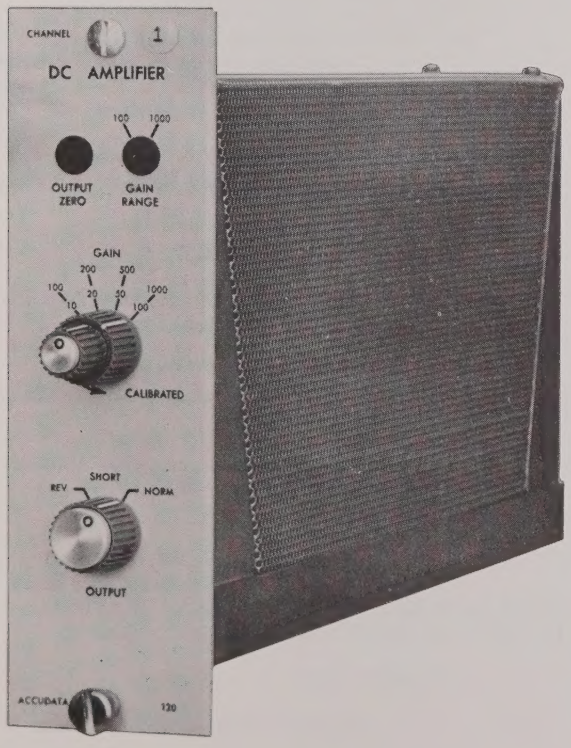

Figure 1-1. Accudata 120 DC Amplifier

Front panel controls provide a combination of gain range, gain stepping, and vernier gain. Front panel switches provide signal polarity reversal and signal output terminal shorting for mechanical positioning of the galvanometer. Optional output terminals are provided to by-pass the polarity reversal feature when driving single-ended devices. A continuously variable control is also provided to zero the amplifier d-c output with no input signal applied.

When used with oscillographic recorders, the Accudata 120 provides positive galvanometer protection. The amplifier prevents transients from damaging the galvanometer when gain ranges are switched, when an open circuit exists, or when the amplifier is turned on or off. If overloads are applied to the amplifier, the output clips or limits, so the galvanometer does not receive excess currents.

Up to eight amplifiers may mount in the standard Honeywell Rack Adapter (Part no. 16902634), Figure 1-2, or seven amplifiers in a Honeywell 16790812 rack, both available for simple installation in a standard 19 inch enclosure. Operating power, input and output receptacles are mounted on the rear panel of the amplifier.

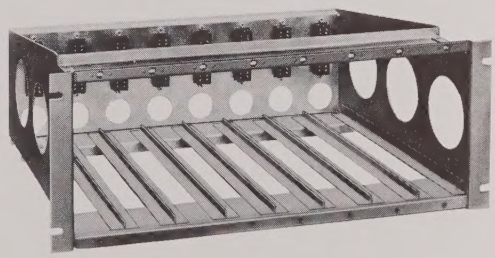

Figure 1-2. Eight-Channel Rack Adapter

1-3. SPECIFICATIONS

A. POWER REQUIREMENTS

1. Line Voltage and Frequency:

a. 790810-001, 105-129 VAC, 50-400 Hz

b. 790810-002, 210-258 VAC, 50-400 Hz

2. Power Consumption:

a. 10 watts maximum with full scale output; 6 watts maximum with no input signal.

b. Power supply providing maximum current to Accudata 105-3: 14 watts maximum with full scale amplifier output; 10 watts maximum with no amplifier input signal.

B. ENVIRONMENTAL

1. Operating Temperature Range: 0° to 50°C

2. Storage Temperature Range: -55°C to +60°C

3. Vibration: MIL-T-21200A, Class 3

4. Humidity: 0 to 95% relative

5. Operating Altitude: Sea level to 10,000 feet

6. Storage Altitude: Sea level to 50,000 feet

C. INPUT

1. Input Voltage Range for Full Scale Output:

a. 2.5 mv to 250 mv

2. Input Impedance:

a. 10 MΩ minimum at dc.

3. Source Resistance: All specifications apply for 0-1 KΩ with up to 1 KΩ unbalance, unless otherwise noted.

4. Differential input current: 50 na dc maximum (20 na typical).

D. OUTPUT

1. Output Capability:

a. Resistive Load: ±2.5 volts and/or 65 ma dc or peak ac from dc to 10 KHz.

b. Parallel RC Loads: ±2.5 volts across resistances greater than 38 Ω and capacitances less than .1 μf from dc to 10 KHz. ±2.5 volts across resistances greater than 1000 Ω and capacitances less than 0.01 μf from dc to 40 KHz.

2. Output Impedance: Less than 1 Ω from dc to 10 KHz.

3. Maximum Capacitive Load: 0.1 μf

E. GAIN

1. Gain Ranges:

a. 10-100 in the "100" position of the GAIN RANGE control, 100-1000 in the "1000" position of the GAIN RANGE control.

2. Calibrated Gain Steps (Vernier in CALIBRATED position):

a. 10, 20, 50, and 100 in the "100" position of the GAIN RANGE control; 100, 200, 500, and 1000 in the "1000" position of the GAIN RANGE control.

3. Vernier Gain Control: Continuously increases the gain between fixed, calibrated steps.

4. D-C Gain Accuracy:

a. Better than ±0.5% when the Vernier Gain control is fully counterclockwise (CALIBRATED).

5. D-C Gain Stability:

a. Less than 0.05%/°C change, with the Vernier Gain control in the CALIBRATED position. Less than 0.1%/°C change with the Vernier Gain control in any position.

6. D-C Gain Linearity: Better than ±0.2% of full scale output (±5 mv) up to full scale output.

F. FREQUENCY RESPONSE

1. Resistive load greater than 36 Ω and capacitive load less than 0.1 μfd:

a. ±2% dc to 10 KHz, up to full scale output; ±5% dc to 20 KHz, up to 80% of full scale output.

2. Resistive load greater than 1000 Ω, and capacitive load less than 0.01 μfd:

a. ±2% dc to 10 KHz, up to full scale output voltage; ±5% dc to 40 KHz; up to full scale output voltage; ±3 db dc to 100 KHz; up to 30% of full scale output voltage.

G. PHASE SHIFT

1. Less than 10° from dc to 10 KHz.

H. DRIFT

1. At a constant temperature, including line voltage changes, over a 24-hour period:

a. Less than ±5 μv RTI (referred to the input) ±200 μv at output.

2. Temperature Coefficient:

a. Less than ±5 μv/°C RTI ±250 μv/°C at output (typically less than ±2 μv/°C RTI ±100 μv/°C at output).

I. NOISE

1. Full Bandwidth

a. Less than 5 μv rms RTI +500 μv rms at output.

2. D-C to 10 KHz Bandwidth

a. Less than 2 μv rms RTI +100 μv rms at output.

J. COMMON-MODE REJECTION

1. Common-mode voltage applied between amplifier common and the input terminals, with the guard shield driven by the CMV:

a. Gains from 100-1000: Greater than 85 db from dc to 400 Hz, with up to 350 Ω source unbalance (100 db with no source unbalance).

b. Gains from 10-100: Greater than 80 db from dc to 400 Hz, with up to 350 Ω source unbalance (90 db with no source unbalance dc to 60 Hz).

K. COMMON-MODE VOLTAGE

1. Maximum common-mode voltage is ±10 volts dc or peak ac.

L. TRANSIENT RESPONSE (Capacitive loads up to 0.01 μfd)

1. Rise time (10-90%): Less than 5 microseconds.

2. Settling time: Less than 20 microseconds to within ±1% of final value.

M. OVERLOAD RECOVERY

1. 10 times overload:

a. Less than 50 microseconds to within ±1% of the final value, at the gain of 1000.

2. Less than 2 milliseconds at other gain settings.

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SECTION II — INSTALLATION

2-1. GENERAL

The Accudata 120 DC Amplifier is wrapped in padding and shipped in a single carton if ordered individually, or it may be shipped in a relay rack if it is a component part of an entire system. Exercise the same care in unpacking this amplifier as would be given any precision instrument.

Installation of the instrument consists of mounting (if used in an equipment rack), and making necessary power and signal connections. Carefully inspect the unit according to paragraph 2-2 before installing.

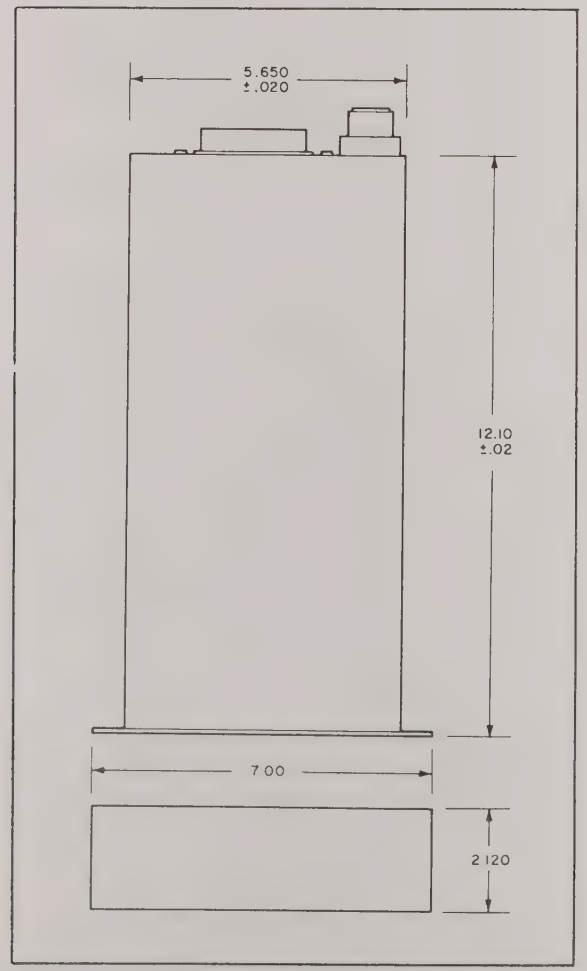


Figure 2-1. Accudata 120 Dimension Drawing

2-2. INCOMING INSPECTION

The Accudata 120 DC Amplifier was mechanically and electrically inspected before shipment. After unpacking, visually inspect the unit for shipping damage. Check for dents, bent panels, cracked or broken control knobs or connectors. Remove the top cover and inspect the circuit card for cracks or damaged components. If physical damage is found, immediately report the extent of damage to the carrier agency and to your Honeywell Sales Representative.

2-3. INSTALLATION

The Accudata 120 DC Amplifier can operate on a bench with or without a Honeywell 16790793 Portable Adapter, or mount in a Honeywell 16902634, or 16790812 Rack Adapter. See Figure 2-1 and 2-2 for dimension diagrams of the amplifier and an 8-channel rack. Electrical connections are made to the amplifier through two connectors on the rear panel; a standard 24 pin Blue Ribbon type connector, Honeywell Number 16100790, and AN-type connector, Honeywell Number 16100058. Mating connector, Honeywell 16750103-025, is available for the AN-type connector. The mating connector for the Blue Ribbon type con-

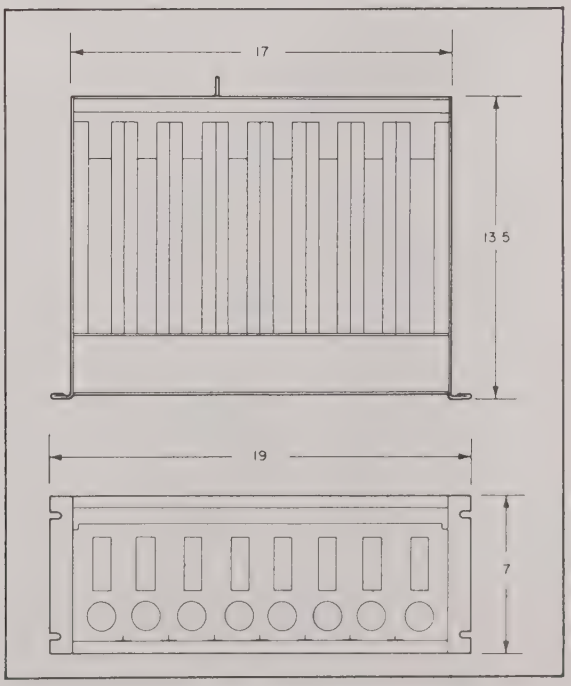


Figure 2-2. Eight-Channel Rack Adapter Dimension Drawing

nector is installed in the Rack Adapter and Portable Adapter, or can be purchased separately as Honeywell Number 16200053.

Before installing the Portable Adapter, remove the Blue Ribbon connector and connect wires to the output terminals, routing them through the grommet provided on the rear of the adapter.

Install the amplifier in the Portable Adapter by sliding the adapter on the amplifier chassis from the rear, mating the Blue Ribbon connector and hold screw on the top of the amplifier front panel. Secure the hold screw to the Portable Adapter. Attach the Support Block, Honeywell Number 16760396, behind the bottom of the front panel, with the hold screw in the front panel.

2-4. WIRING CONNECTIONS

A. GENERAL. Figure 2-3 shows the physical location and designation of connectors on the rear of the Accudata 120. Power and output connections are made to 24 pin connector P1, and input signals are applied to 5 pin connector J1. Pin connections are illustrated in Figure 2-4.

B. POWER. The amplifier operates from a single phase line voltage of 105-129 volts

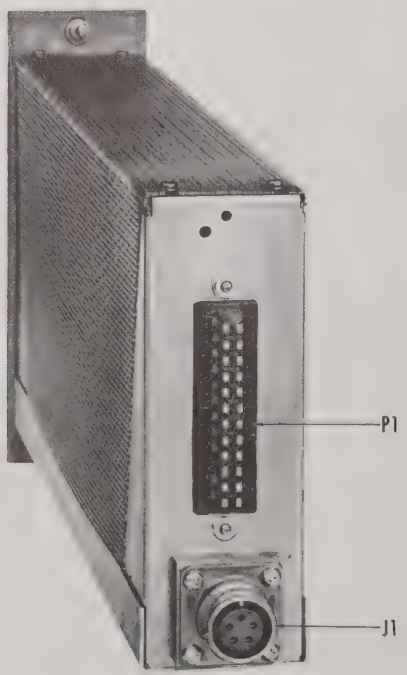


Figure 2-3. Accudata 120 DC Amplifier -Rear View

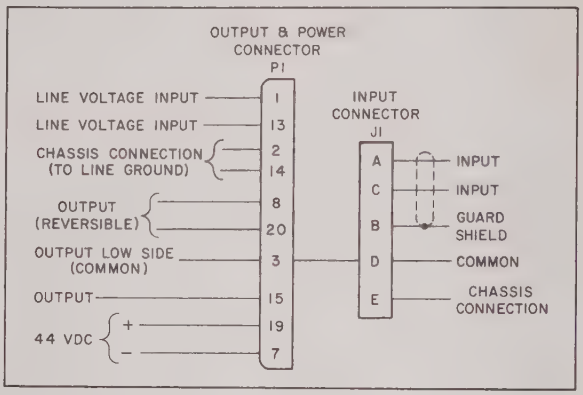


Figure 2-4. Connector Pin Identification

rms, or optional 210-258 volts rms. The line frequency may range from 50 to 400 Hz. Line voltage is applied to the amplifier on pins 1 and 13 of connector P1. A chassis connection, provided on pins 2 and 14, should be connected to power line ground via the ground wire in the line cord, or a separate wire. When plugging the amplifier into 16902634 or 16790812 rack adapters, or 16790793 Portable Adapter, pins 2 and 14 connect to the ground wire in the line cord.

C. OUTPUT. A fixed pair and a reversible pair of amplifier output terminals are provided. The output signal appears between pin 3 (low side) and pin 15 (high side) regardless of the position of the OUTPUT (NORM-SHORT-REV) switch on the front panel. Use these pins when driving single-ended recording devices with one side grounded, such as tape recorders, single-end oscilloscope inputs, etc.. The ground side of the recorder connects to pin 3, and the high side to pin 15. Oscillograph galvanometers and other floating or differential devices can be connected to the reversible output terminals 8 and 20. Pins 8 and 20 connect to the amplifier output through the OUTPUT switch on the front panel. Pin 20 connects to pin 15, and pin 8 to pin 3 in the NORM position of the OUTPUT switch; pin 20 connects to pin 3, and pin 8 to pin 20 in the REV position.

The SHORT position disconnects pin 8 and 20 from the amplifier (also from pins 3 and 15) and shorts pins 8 and 20 together. Pins 3 and 15 are not affected by the short on 8 and 20 and remain connected to the amplifier output. Output connections showing the function of the output polarity reversal switch are illustrated in Figure 2-5.

The amplifier +22 VDC and -22 VDC regulated power supply voltages are brought out to pins 7 and 19. Pin 19 is +22 VDC with respect to common, and pin 7 is -22 VDC. A 44 VDC level appears between the two pins, and supplies up to 50 ma to an external load. Application of this voltage to the Accudata 105-3, 12 volt regulator and Gage Control Unit, provides

a well regulated source of excitation for a strain gage bridge (See section 5-1 F).

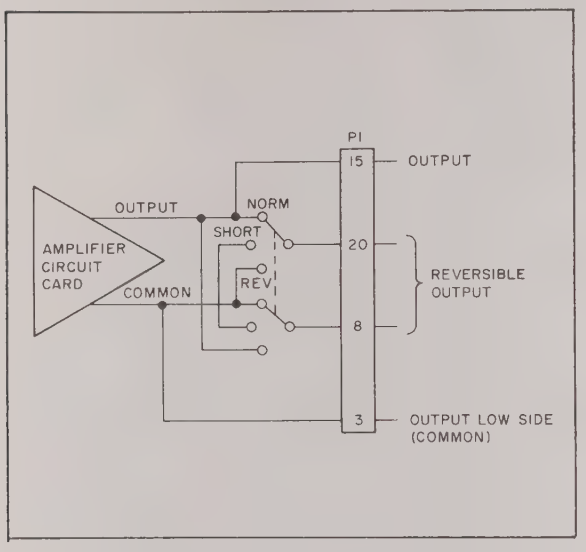


Figure 2-5. Output Connections

D. INPUT. Inputs to the amplifier connect to J1. Pins A and C are the input terminals. Pin A is the "non-inverting" input terminal; i.e., when pin A is positive with respect to pin C, the high side of the output (pin 15) is positive with respect to the low side (pin 3). Pin C is the "inverting" terminal; i.e., when pin C is positive with respect to pin A, the high side of the output is negative. The shield around the input wires inside the amplifier is brought out on pin B as a guard. The guard shield should be driven by the common-mode voltage in a system installation, or grounded if common-mode voltages are not a problem. The amplifier common, or output low side, is also available on pin D. An additional chassis connection is provided on pin E.

Input connections for single-ended operation are shown in Figure 2-6. The single-ended non-inverting connection provides an output signal at pin 15 (or pin 20 when output polarity is NORMAL) of the same phase as the input signal. The single-ended inverting connection provides an output signal at pin 15 (or 20 when output polarity is NORMAL) which is 180° out of phase with the input signal.

E. GROUNDING CONSIDERATIONS. The amplifier and power supply circuitry of the Accudata 120 are isolated from the chassis and the power line. However, sufficient stray capacitive coupling exists causing 60 Hz currents to flow between power line ground and the floating amplifier common (output low side). To prevent these currents from

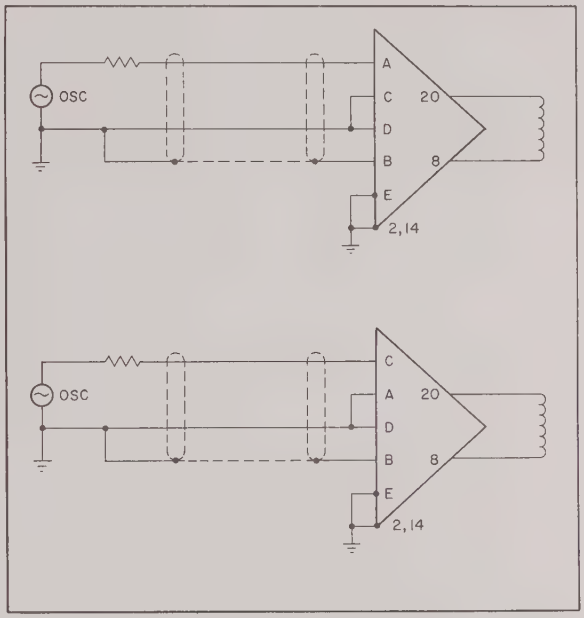


Figure 2-6. Single-ended Connections

adding to common-mode signals, ground the low side of the output at some point in the system. If d-c isolation is desired, use a capacitor (.47 μfd or larger) for this connection.

The best location for the ground connection to the low side of the amplifier output (pin 3 or pin D) depends on whether the source and/or load devices are grounded or floating. Consider the following cases, and recommended ground connections.

1. Grounded load devices, grounded or floating source: the load device grounds the amplifier through pin 3. See Figure 5-4.

2. Floating load device and floating source: Make ground connection at the amplifier (pin 3 to pin 2, or pin D to pin E). See Figure 5-5 .

3. Floating load device, and grounded, single-ended source: Connect amplifier single-ended (one input to common and shield), and ground at the source (see Figure 2-6).

4. Floating load device, and grounded, balanced source: Make ground connection at the amplifier. See Figure 5-4.

2-5. GALVANOMETER MATCHING

A. ELECTROMAGNETICALLY DAMPED GALVANOMETERS. Honeywell M-Series electromagnetically damped galvanometers must be

matched to a critical damping resistance R_d to gain the best compromise between overshoot and frequency response. Proper damping reduces overshoot to a minimum while providing the best flat frequency response. Matching the Accudata 120 output to these galvanometers requires the addition of a series and shunt resistor between the output and galvanometer as shown in Figure 2-7.

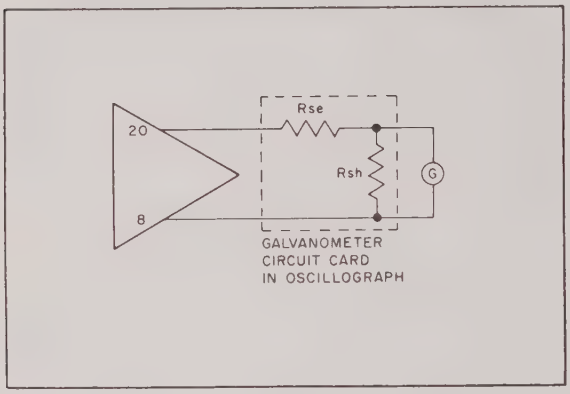


Figure 2-7. Galvanometer Connection

R_{se} and R_{sh} can be mounted on a Honeywell Damping Resistor Card 16306470 in the Visicorder oscillograph.

The values of R_{se} and R_{sh}, required to obtain a specific galvanometer deflection from a known amplifier output voltage, can be calculated from the following equations:

$$R_{se} = \frac{R_d E_o}{I_g (R_d + R_g)}$$

$$R_{sh} = \frac{R_{se} R_d}{R_{se} - R_d}$$

where E_o = Amplifier output voltage

R_g = Galvanometer coil resistance

I_g = Galvanometer current for the required deflection

R_d = Critical damping resistance

The closest MIL values of R_{se} and R_{sh}, which provide full rated deflection of each galvanometer type for full scale amplifier output (2.5 volts), are listed in Table 2-1.

HONEYWELL GALVANOMETER	R_d (Ohms)	R_{se} (Ohms)	R_{sh} (Ohms)
M40-120A	120	63.4K	121
M40-350A	350	130K	357
M-100-120A	120	44.2K	121
M100-350	350	82.5K	357
M200-120	120	16.5K	121
M200-350	350	21K	357
M400-120	120	4.32K	124
M400-350	350	6.19K	357

Table 2-1. Damping Resistors for Electromagnetically Damped Galvanometers for 8 Inch Peak-To-Peak Deflection

B. FLUID DAMPED GALVANOMETERS.

Honeywell M-Series fluid damped galvanometers are damped primarily by fluid action. Source impedances up to 100 Ω have a negligible effect on frequency and transient response. These galvanometers can be driven directly from the Accudata 120 with the following precaution: If the coil resistance of the galvanometer is less than 38 Ω, the full scale amplifier output voltage is less than 2.5 volts; it is equal to the full scale output current (65 ma) multiplied by the coil resistance. Adding sufficient resistance in series with the galvanometer to bring the total up to at least 38 Ω, eliminates this consideration. See Table 2-2.

The maximum safe current for all Honeywell fluid damped galvanometers, and most other similar galvanometers, is 100 ma. The Accudata 120 limits its output current to less than 100 ma under overload conditions, independent of the galvanometer coil resistance.

2-6. OPERATIONAL CHECKOUT

Test the electrical performance of the amplifier per paragraphs 6-6B and 6-6C.3 through 6-6C.4.

2-7. REPACKAGING FOR SHIPMENT

If the original shipping carton is not available, repackage the instrument as follows:

1. Wrap the instrument in heavy paper or plastic before placing in an inner container.

2. Place the unit in a heavy corrugated cardboard inner carton having approximately the inside dimensions as the outside instrument dimensions.

3. Pack dunnage on all sides of the instrument, filling and tightly packing all open areas. Protect panel faces with cardboard strips.

4. Seal the inner carton and place it in a heavy corrugated outer carton.

The outer carton should be large enough to allow a minimum of two inches of dunnage on all sides of the inner package.

5. Tightly pack dunnage between the inner and outer cartons, making certain no voids remain.

6. Seal the container with strong tape or metal bands. Mark the package 'DELICATE INSTRUMENT - FRAGILE".

NOTE

If the instrument is to be shipped to Honeywell - Denver for service or repair, attach a tag to the instrument identifying the owner, and indicate the service or repair to be done. Include the model number and full serial number of the instrument. In any correspondence, always identify the instrument by model number and serial number.

Galvanometer	R_g (ohms)	I_g (ma/in.)	V_g (volts/in.)	Approximate R_{se} (ohms)	Approximate V_c (V/in.)	Resulting operational Range at input (mv/in.)
M1000	39	2.63	.103	0 350	.100 1.00	.1 ---- 10 1 ---- 100 (for ±2.5")
M1650	26.8	9.39	.252	27 82	.500 1.00	.5 ---- 50 1 ---- 100 (for ±2.5")
M3300	32	20	.64	18	1.00	1 ---- 100 (for ±2.5")
M5000	39.5	31.3	1.24	0	1.25	1.25 ---125
M8000	35	40	1.4	28	2.5	2.5 ---- 250
M13000	71	82	5.8	0	5.8	3 ---- 250 (for ±1/2")

NOTE

Other values may be calculated by $\frac{V_c \text{ (desired)}}{I_g} - R_g = R_{se}$

V_c = desired circuit voltage sensitivity = $I_g (R_g + R_{se})$

V_g = galvanometer voltage sensitivity = $I_g R_g$

Table 2-2. Resistor Values for Various Galvanometer Deflections

SECTION III — OPERATION

3-1. GENERAL

This section describes amplifier controls and operating procedures. Thoroughly acquaint yourself with the proper procedures before operating the amplifier and any associated equipment.

3-2. DESCRIPTION OF CONTROLS

A. FRONT PANEL CONTROLS. The following controls are located on the front panel of the Accudata 120 DC Amplifier and perform the functions described. Paragraph numbers refer to the index numbers on Figure 3-1.

1. OUTPUT ZERO. Screwdriver control (accessible through the front panel) used to zero any amplifier d-c output present with no input signal.

2. GAIN RANGE. A two position screwdriver controlled rotary switch (accessible through the front panel) to select one of two gain ranges (100 or 1000).

3. GAIN. A four position rotary switch that varies the amplifier gain in fixed, calibrated steps (10-20-50-100 or 100-200-500-1000), plus a concentric vernier control that increases the gain between steps. The vernier control has no effect when placed in the fully CCW position. The vernier control does not vary the gain when the calibrated control is in the highest position of either gain range.

4. OUTPUT. The output switch is a three position (NORM-REV-SHORT) rotary switch. The NORM position provides normal signal polarity output. The REV position reverses the polarity of the signal output. The SHORT position shorts the output for mechanical positioning of a galvanometer.

3-3. OPERATING PROCEDURES

Use the following procedure when operating the Accudata 120 in an oscillographic recording system.

A. Before applying power to the system, set the amplifier OUTPUT switch to the SHORT position.

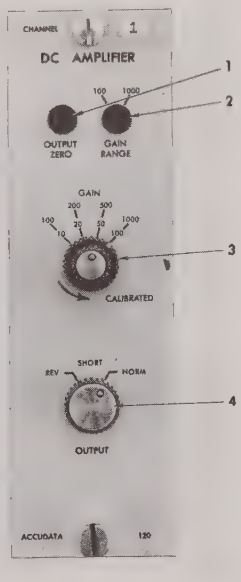


Figure 3-1. Front Panel Controls

B. Mechanically position the galvanometer light spot on the record.

C. Set the amplifier GAIN switch to 10.

D With no input signal, but with a source attached (or input shorted and returned to common), set the OUTPUT switch to NORM (normal) or REV (reverse) polarity.

E. Adjust the amplifier OUTPUT ZERO control with a small screwdriver to return the galvanometer light spot to its mechanical zero position.

F. Increase the amplifier gain gradually (if required) and adjust the OUTPUT ZERO as required to return the galvanometer to mechanical zero.

G. Return the amplifier gain to 10, and apply the input signal. Increase the amplifier gain gradually until reaching the desired galvanometer deflection.

SECTION IV — PRINCIPLES OF OPERATION

4-1. INTRODUCTION

The Accudata 120 is a solid state d-c amplifier capable of amplifying low-level signals to the level required to drive fluid damped galvanometers or other data recording devices. The amplifier has a high impedance differential input and a low impedance single-ended output to provide maximum flexibility of application, and to minimize loading of the source. High d-c stability and good common-mode rejection is achieved without choppers or transformer coupling. A well regulated d-c power supply is an integral part of the amplifier package.

4-2. AMPLIFIER CIRCUIT DESCRIPTION

The over-all amplifier consists of two independent feedback amplifiers, in tandem, as shown in Figure 4-1. Both amplifiers are supplied plus and minus 22 volts dc from a common power supply. The gain of the over-all amplifier is the product of the gain of the preamplifier and the attenuation or gain of the power amplifier. The preamplifier has two fixed gain settings (50 or 500), selectable by the GAIN RANGE control. The attenuation and gain of the power amplifier is varied in fixed steps of .2, .4, 1.0, and 2.0 by the GAIN control, and varied between fixed positions by the vernier gain control. Refer to the schematic diagram at the rear of this manual during review of the following circuit descriptions.

A. PREAMPLIFIER. The preamplifier section consists of three stages of differential amplification, followed by a single-ended output stage. The open loop gain of these stages is a minimum of 100 db. This high loop gain provides good linearity, a stable and accurate closed loop gain, and low drift. The gain accuracy and stability are determined primarily by the characteristics of the wirewound feedback resistors; the drift is a function of the source resistance and the matching of the input transistors. Common-mode feedback is applied around the first

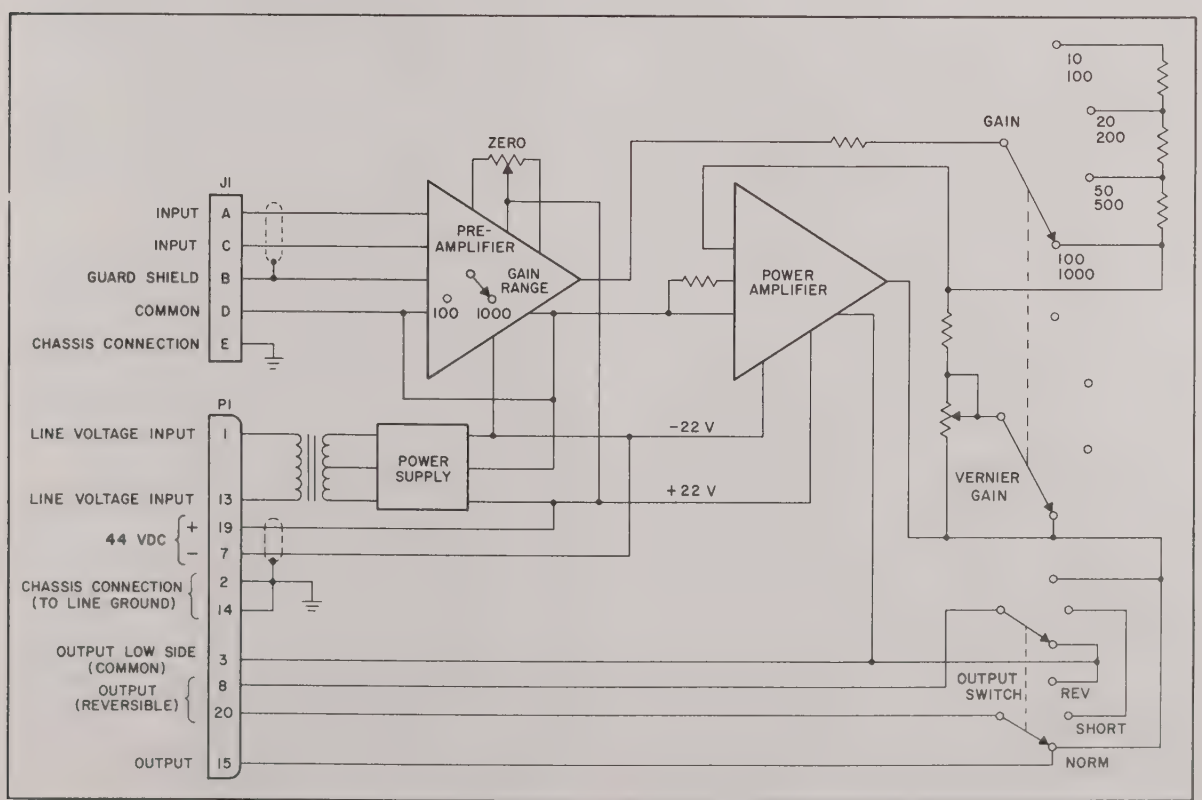


Figure 4-1. Accudata 120 - Block Diagram

two stages to improve the rejection of common-mode voltages.

The input signal is applied to input transistor pair Q1 through pins A and C of the printed circuit connector J-2. A resistor network supplies base currents to transistor Q1, and eliminates the need for an external return path for these currents. The base currents are supplied through resistors R64 and R65 from an adjustable voltage divider consisting of resistors R66, R67, and R68. Trimpot R67 adjusts the voltage level at the junction of R66 and R68 to provide the precise amount of base current needed by Q1.

The first stage consists of a differential transistor pair Q1, with a controlled current source common to both emitters. Components of the current source are transistor Q9, zener diode VR3, and associated resistors. The collector circuit of Q1 is composed of R1, R2, and the OUTPUT ZERO trimpot R3, which adjusts the collector current balance between the two transistors. Emitter resistors R4, R63 and trimpot R5 compensate for the base-emitter voltage mismatch of Q1 to prevent the d-c voltage level at the output of the preamplifier from changing with preamplifier gain. R5 also acts as a coarse output zero control.

Q1 is a pair of silicon planar transistors mounted in a common TO-5 package. The d-c current gains (H_{FE}) and base-emitter voltages are closely matched at room temperature, and remain within a specified range of each other as temperature varies. The change in base-emitter voltage difference with temperature is less than 3 μv/°C, and is the most important factor in determining the over-all drift of the amplifier. Other resistors in the emitter circuit of the first stage are associated with the over-all feedback network and are discussed later.

The amplifier signal appearing between the collectors of transistor pair Q1 is applied to the second differential stage consisting of Q2-A and B, Q3-A and B, and R14 through R21. Each side of the second differential stage is composed of a Darlington-connected transistor pair. The Darlington connection boosts the input impedance of the stage, thus keeping the gain of the first stage high. Emitter resistors R16 and R17 provide some degeneration to stabilize the gain of the stage and increase its input impedance. The common emitter resistance of this stage consists of R14 and R15. The junction of R14 and R15 connects to the base of common-mode amplifier Q6. Q8 amplifies common-mode signals appearing at the junction of R16 and R17 and inverts the phase of these signals.

The amplified signal is applied to the emitter of controlled current source Q9. The base of Q9 is biased at a fixed voltage by diode VR3, and variations in the emitter voltage change the collector current of Q9. The change in collector current adds or subtracts current from transistor pair Q1 to maintain constant collector currents. If the collector currents are constant, as the common-mode signal is applied to the base terminals, the common-mode voltage will not be amplified.

The R-C networks between the collector and base terminals of the second stage shape the open loop gain and phase characteristics of the preamplifier to provide a stable feedback loop. The output of the second stage is applied to the third differential stage, composed of Q4, Q5, R26, R27, and R28. Emitter resistors R26 and R27 stabilize the gain of the stage and increase its input impedance. The common-emitter resistor R28 is returned to the -22 volt supply.

The amplified output of this stage is taken between the collector of Q5 and amplifier common to convert to a single-ended output. The signal is applied to the output stage consisting of transistors Q6 and Q7, bias diodes CR1 and CR2, and associated resistors. The signal is amplified by Q6 and applied to the output and to Q7 through CR1 and CR2. Q7 provides current amplification and acts as a dynamic collector resistor for Q6 to improve the efficiency of the stage. The voltage across diodes CR1 and CR2, the base-emitter voltage of Q7, and resistors R31 and R32 determine the no-signal current through Q6 and Q7.

Overall feedback is applied around the preamplifier through feedback resistor R34. The feedback network consists of R34, and R6 through R11. R34 and R6 determine the gain when GAIN RANGE switch S1 is in the 100 position. Emitter resistor R7 and the resistance to common, consisting of R9, R10, and R11, are necessary to complete the symmetry of the feedback network, but have a small effect on the closed loop gain.

In the 1000 position of the GAIN RANGE control, R6 is shunted across R7 and R8 to increase the gain to 500. Shunting R7 and R8 with R6 is equivalent to shunting one half of R6 across feedback resistor R8. This method of changing the gain does not affect the balance of the first stage, and reduces switching transients to a minimum. Trimpots R9 and R10 are switched into the balance network individually by the GAIN RANGE control. These trimpots are adjusted to cancel common-mode output signals which are not rejected by the common-mode feedback. These common-mode signals are the result of unbalances between the two input transistors. They are fed back to the emitters of the first stage, and cancelled by unbalancing the feedback network.

The output of the preamplifier is routed through R61 to pin K of connector J2. From J2 the signal passes through GAIN switch S2 on the front panel, and returns to the power amplifier on the circuit card through J2-L. R56 through R61 are components of the resistive operational feedback around the power amplifier. This network establishes the calibrated gain steps of the overall amplifier.

B. POWER AMPLIFIER. The power amplifier section is an inverting current ampli-

fier with operational voltage feedback around it. The amplifier consists of two stages of voltage gain followed by three stages of current amplification. The output voltage is fed back to the input terminal of opposite phase and summed with the signal from the preamplifier. The closed loop gain (or attenuation) of the power amplifier is determined by the ratio of the feedback resistance from the output to the input, divided by the resistance from the preamplifier output to the input of the power amplifier. The ratio of these resistors provides fixed attenuation or gain. The low closed loop gain assures that the power amplifier will have a small effect on the drift and noise of the over-all amplier. It also eliminates output transients when switching gain positions of the over-all amplifier. The attenuation steps are .2, .4, 1.0, and 2.0. Vernier gain control R60 is is series with feedback resistor R59 and varies the attenuation of the power amplifier between the fixed, calibrated values.

The first stage of the power amplifier is a balanced differential stage, consisting of Q10-A and B, and resistors R36 through R40. The base of Q10-A is the input to the amplifier, and the base of Q10-B is returned to common through drift stabilizing resistor R35. Q10-A and Q10-B are matched for d-c current gain (H_{FE}) and base-emitter voltages, and cemented together with thermal conducting epoxy. Matching these transistors and reducing the thermal gradient between them insures that the power amplifier contribution to the over-all drift will be small.

The R-C network across the output of the first stage shapes the open loop gain and phase characteristics.

The output of the first differential stage is applied to second stage transistors Q11 and Q12. This stage is differential, with emitter resistors R43 and R44 connected to common emitter resistor R46. The emitter resistors stabilize the gain of this stage and increase its input impedance. Use of PNP transistors allows placement of the collector bias near the zero volt level, required by the remaining emitter-follower stages.

The output of the second stage is taken between the collector of Q12 and common and applied to emitter-followers Q13 and Q14. Transistors Q13 and Q14 provide sufficient current gain to drive the output stage. The output stage is a PNP-NPN stage, operating class AB to minimize the no-signal power dissipation. The no-signal current through Q15 and Q16 is determined by the voltage across CR3, CR4, CR5, the base-emitter voltages of Q16 and Q17, and resistors R49 and R50. Resistors R47 and R48 limit the dissipated power in Q15 and Q16 at full scale output, and in conjunction with R49 and R50, limit the maximum current output of the amplifier. The signal at the emitter of transistor Q14 is applied to the base of Q15 and Q16 through diodes CR3, CR4, and CR5. Since the transistors are of complementary types, the same base drive signal reduces the collector current through one, while increasing the current through the other.

The output of the amplifier is fed back to the input terminal through feedback resistor R59 and vernier control R60. The feedback network consists of resistors R56 through R58, and R61 and R62. Close-tolerance wirewound resistors are used to insure long term stability and a stable attenuation with changes in temperature. The output of the power amplifier is routed through J2-U to the OUTPUT switch. Capacitor C7 is a permanent capacitive load on the amplifier, reducing the range of capacitive loads over which the amplifier must be stable.

C. POWER SUPPLY. The power supply section provides regulated plus and minus 22 volts dc from either a 115 volt ac or 230 volt ac line voltage.

The line voltage is applied to transformer T1. The primary of T1 is divided into two identical windings, externally connected in series or parallel. The windings are connected in parallel for 115-volt inputs, and in series for 230-volt inputs.

The center-tapped secondary voltage of T1 is applied to a full wave diode bridge, connnected to provide full wave positive and negative rectification with respect to the center-tap. The positive and negative d-c voltages are filtered by capacitors C8 and C9, and applied to separate regulating circuits. Both regulators are identical except for the polarity of transistors and diodes; a PNP series pass transistor Q18 is used in the negative voltage regulator, and an NPN transistor Q17, in the positive regulator.

The unregulated d-c voltages are applied to a preregulator, consisting of VR4 and R53 in the negative regulator, and VR5 and R52 in the positive regulator. The fixed 24 volts across VR4 and VR5 is used as a stable, relatively ripple-free voltage supply for reference diodes VR1 and VR2. Current through VR1 and VR2 is determined by the voltage across resistors R54 and R55 and is relatively constant. VR1 and VR2 provide a stable reference voltage of 22 volts ±1% to the base of the series pass transistors. The output of the regulated supplies is filtered further by capacitors C10 and C11. C10 and C11 also reduce the output impedance of the supplies.

The regulated voltages from the power supply are applied to the Preamplifier, Power Amplifier, and to pins 7 and 19 of output connector P1. The voltage between pins 7 and 19 is 44 volts dc and is capable of supplying up to 50 ma to an external load.

SECTION V — APPLICATIONS

5-1. SOURCE CONSIDERATIONS AND TRANSDUCERS

A. GENERAL. Transducers basically convert energy from one form to another. In this section, transducers are considered low-level and high-level signal sources and are treated separately. Certain other sources, best handled by other amplifier techniques, are also discussed.

Generally, a transducer can be dealt with in terms of its Thevenin equivalent, (the EMF acting in series with an impedance), and the bandpass specifications of the transducer. Figure 5-1 illustrates a Thevenin equivalent. Source output appear to the amplifier as either a variation in source voltage, E_s source impedance, R_s, or both.

B. LOW-LEVEL INPUTS. The majority of transducers falls into the low-level input category. This discussion defines low-level inputs (inputs best handled by the Accudata 120) as those having an output voltage in the range from 2.5 to 250 mv, with source impedances between 0 and 1000 ohms. The Accudata 120 can also satisfactorily handle source source impedances higher than 1000 ohms. The 1000 ohm specification defines the other points in the published specifications, especially noise. The noise level of the amplifier normally doubles as the source impedance quadruples (with a 4000 ohm source, twice the published specification noise can be expected). Often this noise level increase is negligible, considering the published specifications are worst-case conditions.

C. THERMOCOUPLE SOURCES. Typical thermocouple source EMF varies between 0 and 1 mv and 0 to 80 mv, depending on the type of thermocouple material and the temperature range involved. Thermocouple EMF tables are available from all Honeywell Branch Sales Offices.

The reference junction, shown in Figure 5-2, varies in complexity from a triple point cell to an ice bath, to a bottle of water, or a heavy metal heat sink. The only requirement at the reference junction is that it be more stable than the least signal of interest at the measuring junction.

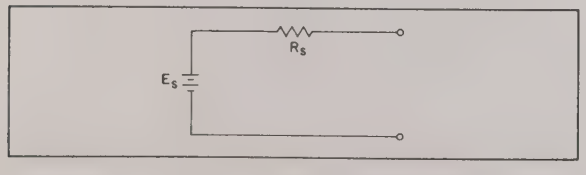


Figure 5-1. Thevenin Equivalent Circuit

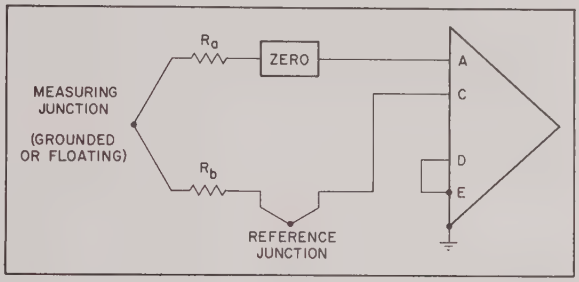


Figure 5-2. Thermocouple Circuit

The output EMF of the thermocouple is proportional to the difference between the reference junction and the measuring junction. Positive output signals are generated when the measuring junction is above the reference junction temperatures, with negative output signals generated when the measuring junction is below the reference junction temperature. A commonly used reference junction is similar in construction to a crystal oven, and the reference temperature is maintained above the ambient by external heating.

When working with thermocouple EMF tables, it is necessary to subtract the EMF generated, at a given temperature of the reference, from the EMF generated at the measuring junction. A small error, which often becomes significant, results if the two temperatures are subtracted directly, as the thermocouple EMF curve is slightly parabolic.

Often electrical zero suppression networks are required, particularly when the area of measurement differs greatly from the reference temperature area. For example: In jet engine exhaust temperature measurements, the only area of interest lies between 1200 and 1400 degrees. The area between 32° and 1200° offers no significant data. In this case, an EMF is generated in the box marked "ZERO" in Figure 5-2, which is equal in amplitude and opposite in polarity to the EMF of the thermocouple at 1200°.

The thermocouple source impedances, as seen by the amplifier inputs, are:

1. Combination of resistance of the hot leg and cold leg, and depend upon the:
   a. Wire diameter.
   b. Wire material.
   c. Length of thermocouple wire.
   d. Ambient temperature.

2. Resistance of the zero suppression circuit in one lead constitutes a source unbalance.

D. STRAIN GAGE MEASUREMENTS. Figure 5-3 schematically illustrates the strain gage input configuration. The output voltage of a typical strain gage varies between 0 and 10 mv; output impedance is typically 120 or 350 ohms. Output voltage may be adjusted by using the SENS rheostat illustrated in the control unit. An increase in the exciting voltage of one volt usually increases the output of the gage by 1 mv or 2 mv, depending on the gage factor. The gage factor is the ratio of the input or excitation voltage in volts to the output voltage in millivolts. The unit of the gage factor is millivolts per volt.

The power supply output is approximately 12 volts, and the series resistor for sensitivity should reduce this by a factor 10 to 1. The zero adjust potentiometer is usually in the range from 5K-50 Ω and serves to balance out unbalances in the bridge resistors. Pad resistor R_{sh} serves as a replaceable resistor, adjusting the sensitivity of the balance adjustment. The output millivoltage is developed across pins C and A of the control unit and coupled to amplifier input pin C. A ground connection is required to the amplifier common (pin D or pin 3) as shown in Figure 5-4.

Using the interval power supplies of the Accudata 120 as a source of gage excitation voltage is discussed in paragraph 5-1 F.

E. THERMISTOR TEMPERATURE SENSING DEVICES. Thermistors are semiconductor devices displaying large changes in resistance for small changes in temperature. They are widely used for measurement of temperatures having very narrow temperature ranges.

Figure 5-5 illustrates the input configuration of a thermistor bridge to a bridge balance.

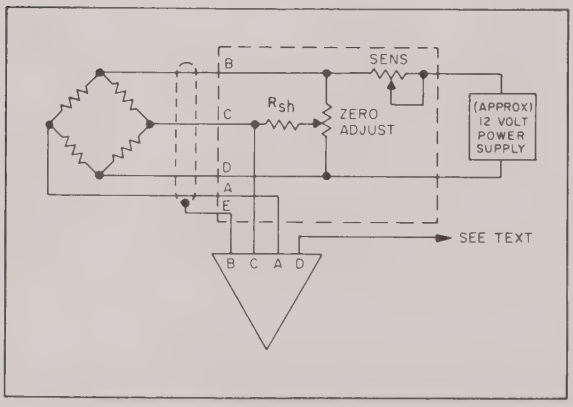


Figure 5-3. Strain Gage Circuit

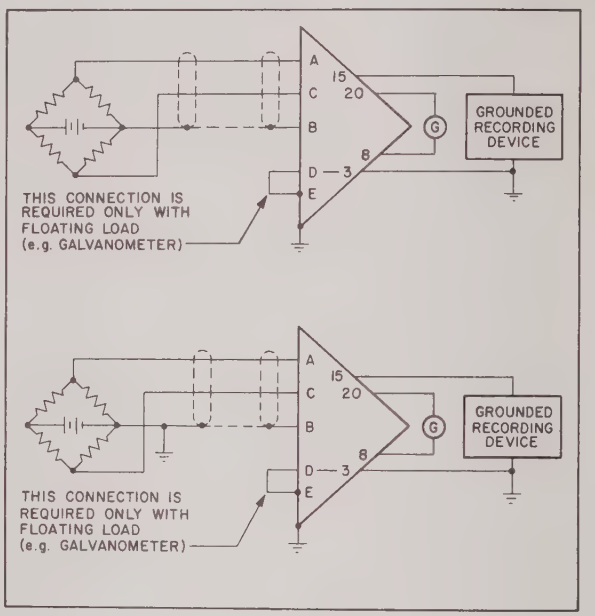


Figure 5-4. Typical Strain Gage Channels

Values for T_t, the dummy resistors used in the external bridge, should be adjusted to equal the thermistor resistance at the middle of the thermistor operating range. This information is normally available from the manufacturer's specifications.

A typical thermistor output, for use with the Accudata 120, would be source voltages varying between approximately 2.5 and 100 millivolts, and source impedances running from 500 to as high as 8000 ohms. The resistance of the device generally varies inversely with the size of the thermistor.

Using the internal power supplies of the Accudata 120 as excitation for the thermistor bridge is discussed in paragraph 5-1 F.

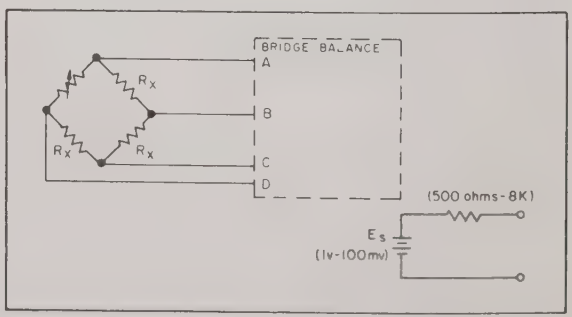


Figure 5-5. Thermistor Bridge Circuit

F. ACCUDATA 120/ACCUDATA 105-3 CHANNELS. A low cost strain gage or thermistor bridge channel can be constructed using the Accudata 105-3 Gage Control module in conjunction with the Accudata 120. The Accudata 105-3 contains a voltage regulator that accepts the 44 volts dc output of the Accudata 120 power supplies and provides a 12 volt excitation voltage. This 12 volt dc supply is capable of supplying up to 40 ma of current to the bridge. The excitation voltage applied to the bridge can be varied with the EXCITATION control on the front panel of the Accudata 105-3. Bridge balance, calibration, and polarity reversal features are also provided on this module. Figure 5-6 illustrates the connection between the two modules in a typical measurement channel.

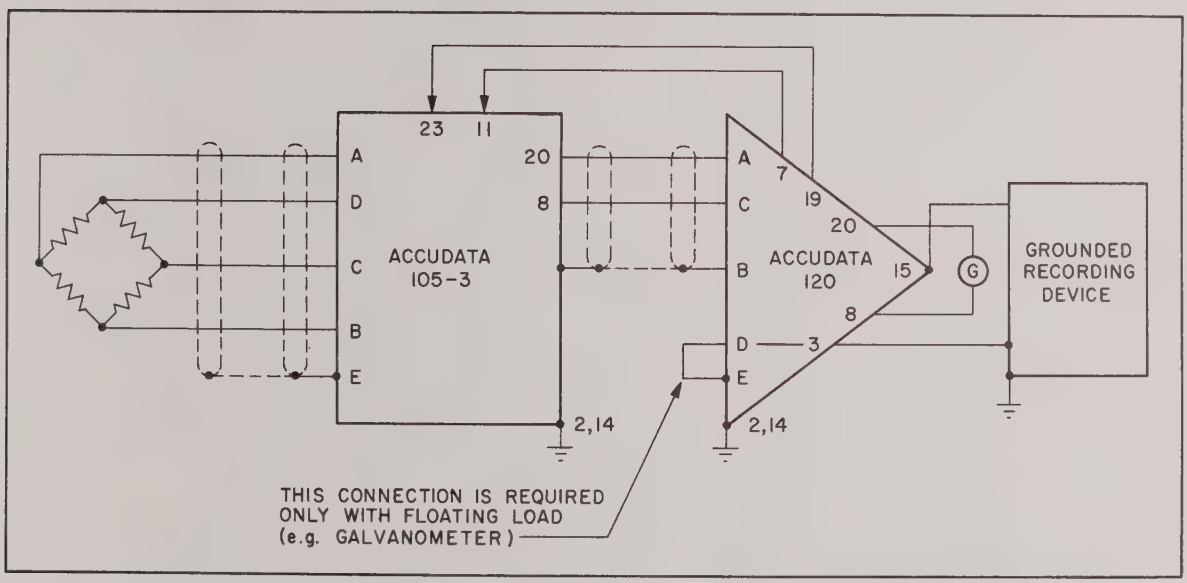


Figure 5-6. Connections to Accudata 105-3

SECTION VI — MAINTENANCE

6-1. GENERAL

This section contains preventive and corrective maintenance procedures for the Accudata 120. Preventive maintenance outlines routine procedures to be performed at regular intervals without special tools and test equipment. Corrective maintenance includes basic troubleshooting, replacement, and adjustment information. Corrective maintenance information aids the technician in determining the cause of a malfunction, but does not detail the action to be taken upon localizing it. Using the schematic diagram, the technician should determine the best method for correcting the malfunction.

6-2. PREVENTIVE MAINTENANCE

Periodically perform the following procedures to maintain the operability of the equipment and to prevent future malfunctions.

A. INSPECTION. Perform an occasional over-all visual inspection of the unit. See that the printed circuit card is securely fastened, all receptacles tight, no loose or broken connections, no bent or corroded pins. Check that the equipment is clean.

B. CLEANING. Remove dust and loose dirt from the unit with a brush and a vacuum hose. Remove deposits of dirt, grease, or oil from metallic parts with a cloth moistened with any commercial dry cleaning solvent (petroleum solvent). Clean non-metallic parts with a lint-free cloth moistened with plain water.

6-3. TEST EQUIPMENT

The tools and test equipment recommended for troubleshooting and checkout of the Accudata 120 DC Amplifier are listed in Table 6-1. This list is not mandatory, but should be used as a standard if alternate equipment is selected.

6-4. CORRECTIVE MAINTENANCE

A. GENERAL. Malfunctions are normally indicated by irregular action of galvanometer light spot on the recording plane. If the malfunction is isolated to the amplifier, remove it from the rack adapter and carefully check all leads, connectors, and components for visible damage, such as broken leads, burnt or damaged components, or poor solder connections. If visual inspection fails to pinpoint the defect, refer to the subsequent troubleshooting procedures.

NOTE

If proper test facilities and equipment are not available to troubleshoot and repair this unit, contact your local Honeywell Sales and Service representative. Honeywell branch offices are staffed with factory trained engineers, equipped to make effective repairs in a minimum amount of time.

B. TROUBLESHOOTING. This paragraph contains troubleshooting tables and step-by-step procedures for maintaining the preamplifier, power amplifier, and the power supply. Determine the cause of amplifier malfunctions as follows:

NOTE

Before troubleshooting this unit, the maintenance man should thoroughly acquaint himself with Section IV, Principles of Operation.

1. Preamplifier

a. General. A preamplifier malfunction is often indicated by a saturated output (J2-K). With the preamplifier at saturation, the OUTPUT ZERO control has no effect on the output level. Troubleshoot the preamplifier with the amplifier unit removed from the rack adapter. Refer to the schematic diagram for normal voltage levels.

MANUFACTURER	MODEL NO.	DESCRIPTION
Honeywell	852	DC Differential Voltmeter
Hewlett-Packard	HP400H	AC VTVM
Hewlett-Packard	HP3400A	AC VTVM (True RMS)
Hewlett-Packard	HP200CD	Oscillator
Tektronix	531	Oscilloscope
Triplett	630-NA	Multimeter
Unger	30 watt	Soldering iron
		Regulated D-C Power Supply (Variable)
		Bench Test Adapter Cable
		Standard Shop Tools

Table 6-1. Recommended Tools and Test Equipment

b. Troubleshooting Table. Table 6-2 shows possible causes and remedies for various preamplifier malfunctions.

NOTE

Resistance and capacitance values and transistor parameters in this unit are critical. Replace only with recommended parts listed in the electrical parts list, Section VII.

c. Troubleshooting Procedure. When troubleshooting the preamplifier printed circuit card, use the following procedures.

1) Using a high impedance voltmeter, check voltage levels starting from the output stage and working backward. Correct voltage levels, as listed on the schematic diagram, indicate correctly operating stages on the output side of the measurement location.

2) Check transistors by measuring the base-to-emitter voltages. Indications should be between 0.5 and 0.7 volts dc.

2. Power Amplifier

a. General. The power amplifier circuit contains the gain attenuator switch assembly. Before troubleshooting, make certain that all switch positions and connections are proper. Troubleshoot the power amplifier with the amplifier unit removed from the rack adapter. Refer to the schematic diagram for normal voltage levels.

b. Troubleshooting Table. Table 6-3 provides information on possible causes and remedies for various power amplifier malfunctions.

NOTE

Resistance and capacitance values and transistor parameters in this unit are critical. Replace only with recommended parts listed in Section VII.

c. Troubleshooting Procedure. When troubleshooting the power amplifier printed circuit card, use the following procedures.

1) Using a high impedance voltmeter, check voltage levels starting from the output stage and working backward. Correct voltage levels, as listed on the schematic diagram, indicate correctly operating stages on the output side of the measurement location.

2) Check transistors by measuring the base-to-emitter voltages. Indications should be between 0.5 and 0.7 volts dc.

SYMPTOM	POSSIBLE CAUSE	REMEDY
No output signal	Improper input connection to amplifier. No power to amplifier.	Make certain inputs are connected. Check power input connections.
Excessive drift.	Defective transistors Q1-A, Q1-B. Power supply drift.	Replace transistor assembly Q1. See Table 6-4.
Noise - 120 Hz - 60 Hz	Power supply defect. Improper input cable shielding. Value change of components C1, R22, R24, C3, C12, C2, R23, R25, C4, C5.	See Table 6-4. Check shields for proper grounding. Check values and replace if necessary.
Failure to obtain zero output using OUTPUT ZERO control.	Improper adjustment of R5. Defective control R3, R5. Defective transistor assembly Q1.	Adjust R5: refer to para. 6-7. Replace R3, R5. Replace Q1.
Improper gain.	Gain switch S1 in wrong position. Value change in feedback circuit components R34, R6, R7, R8.	Properly position S1. Check values and replace if necessary. Adjust for proper output. Check values and replace if necessary.

Table 6-2. Preamplifier Troubleshooting Table

3. Power Supply

a. General. The power supply components, with the exception of transformer T1, mount on the amplifier printed card. The supply provides positive and negative 27 to 38 volts dc at the output of the diode bridge rectifier. This voltage drops to positive and negative 22 volts dc at the supply output.

b. Troubleshooting Table. Table 6-4 provides possible causes and remedies for various power supply malfunctions.

c. Component Checkout. Check power supply components using an ohmmeter. Starting at source pins 1 and 13 of connector, check continuity of the transformer primary and secondary. Check capacitors C8, C9, C10, and C11 for a charge indication on the ohmmeter. Check resistance values of R52 through R55.

6-5. REPAIR AND REPLACEMENT

A. Determine the need for repair or replacement of parts by inspecting the amplifier according to paragraph 6-2. Replace any defective parts and resolder any loose leads or poor solder connections.

B. REPLACEABLE PARTS. Refer to Section VII for a complete list of electrical parts. To ensure safe, efficient operation, use only parts with the electrical characteristics and tolerances listed.

C. CIRCUIT CARD REPAIR. Exercise caution when removing or replacing compo-

SYMPTOM	POSSIBLE CAUSE	REMEDY
No output signal.	No input signal to power amplifier. Switch S2 or S3 in wrong position or defective. Defective transistors.	Refer to preamplifier; see Table 6-2. Properly position S2 and S3, or replace if necessary. Check transistors. Refer to para. 6-4, 2.C.
VERNIER GAIN control has no effect on amplifier sensitivity.	Shorted potentiometer R60.	Replace R60
Improper gain.	Value change of R56 - R62.	Check values and replace if necessary.
Excessive change in d-c output level when GAIN RANGE control switched.	Improper alignment of R5 in preamplifier. Defective transistor pair Q10A, B.	Refer to calibration procedure, para. 6-7. Replace transistor.

Table 6-3. Power Amplifier Troubleshooting Table

SYMPTOM	POSSIBLE CAUSE	REMEDY
No Power Supply output.	Improper a-c source connection. Transformer T1 primary or secondary open. Defective diode bridge. Shorted filter capacitors. Transistors Q17 or Q18 defective.	Check a-c line voltage pins 1 and 13 of connector P1. Replace T1. Replace bridge CR6. Replace C8, C9, C10, or C11. Replace Q17 or Q18.
Noise on supply output.	Deteriorated or open filter capacitors.	Replace C8, C9, C10, or C11.
Incorrect power supply output.	Defective regulator zener diodes, transistors, or resistors. Defective diode bridge.	Replace VR1, VR2, VR4, VR5, R52 thru R55, or Q17, Q18. Replace bridge.

Table 6-4. Power Supply Troubleshooting Table

nents from the amplifier printed circuit card, especially when a component has multiple pins and each pin must be unsoldered individually. Too much heat applied to a small area may scorch the copper clad and loosen it from the card. To remove or replace circuit card components, use an iron of the Unger type with no more than a 30 watt tip and perform the following:

1. Dip the end of a braided shield or ground type strap in solder flux, and place the flux end of the strap over the point where solder is to be removed.

2. Place the iron on the strap, directly over the terminal. Capillary action will draw the solder from the hole into the strap.

6-6. PERFORMANCE TESTS

A. GENERAL. The Accudata 120 DC Amplifier was thoroughly tested before shipment from Honeywell. The following procedures are intended to familiarize the user with the test methods used by Honeywell during final checkout of the Accudata 120. Use of these procedures is recommended in any further tests performed at the user's facility to provide consistency in the results.

B. INITIAL PREPARATIONS. The following preparations should be made before performing any tests on the Accudata 120.

1. Connect the amplifier input to the test circuitry recommended for the specific test to be performed.

2. Allow the amplifier 15 minutes warmup.

3. Set the amplifier to the desired gain setting and the OUTPUT switch to NORM.

4. With no input signal applied, connect a differential voltmeter to the output and adjust the OUTPUT ZERO control until the d-c output voltage is 0 ±10 millivolts.

C. TEST PROCEDURES

1. Frequency Response

a. Connect the amplifier as shown in Figure 6-1. R2 should be a multiturn potentiometer to provide the required resolution. Select R1 to provide the necessary attenuation at the desired gain setting of the amplifier. The load resistance and capacitance can be any value within the load specifications.

b. See Initial Preparations (paragraph 6-6.B).

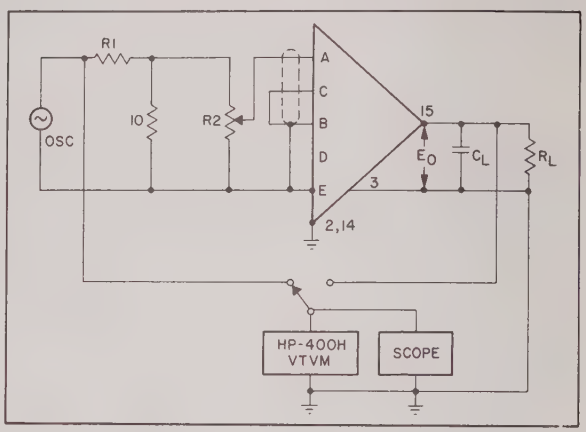


Figure 6-1. Frequency Response Test Circuit (G>1)

c. Adjust the oscillator to 1.8 volts rms or less at 100 Hz with the H-P 400H VTVM.

d. Adjust R2 until the amplifier output voltage is precisely the same as the oscillator voltage. Switch the voltmeter between the oscillator and amplifier output several times, adjusting R2 until no difference exists between the voltage readings.

e. Observe the output voltage on the oscilloscope for distortion. If distortion is present, determine the cause and correct it before proceeding.

f. With no further adjustment of R2, switch the oscillator frequency through settings of 500, 1000, 3000, 5000, and 10,000 Hz. Adjust the oscillator amplitude at each frequency to maintain the original voltage. Record the amplifier output voltage at each frequency. Calculate the deviation from a flat response at each frequency relative to 100 Hz.

NOTE

This procedure uses a response reference point of 100 Hz. If desired, use dc as the reference by replacing the oscillator with a d-c power supply and adjusting R2 with a d-c voltmeter instead of the H-P 400H.

g. Response to frequencies above 10KHz is specified at less than full scale output (see specifications). Reduce the oscillator output to the appropriate level for the specific load impedance being used and the highest frequency to be tested. Return the oscillator frequency to 100 Hz and repeat steps d, e, and f; then check the frequencies above 10KHz.

2. D-C Gain Linearity

a. Connect the amplifier as shown in Figure 6-2. Use a well regulated d-c power supply capable of supplying at least 10 volts. R1 should be a 1000 ohms, multi-turn potentiometer to provide adequate resolution. Select R2 to provide the necessary attenuation at the desired gain setting of the amplifier.

b. See Initial Preparations (paragraph 6-6.B).

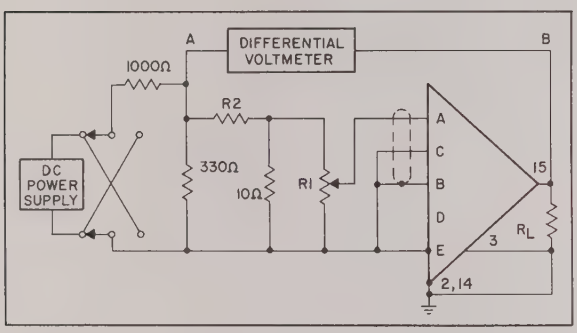


Figure 6-2. D-C Gain Linearity Test Circuit

c. Set R1 so that no voltage is applied to the amplifier.

d. Adjust the amplifier OUTPUT ZERO until the voltage indicated by the differential voltmeter is zero.

NOTE

Due to the resolution of the zero control, it is only possible to zero the amplifier to within ±5 mv.

e. Adjust the voltage dials on the voltmeter for a null.

f. Adjust the power supply until the voltage at point A is +2.5 volts.

g. Adjust R1 until the voltage between A and B, as indicated on the differential voltmeter, returns to the null point established in step "e".

h. Reduce the power supply voltage until the voltage at point A is again zero volts. Note: Short the output of the power supply to eliminate any residual voltage. If the reading differs from that established in step "e", repeat steps "e", "f", and "g", until the differential voltmeter indicates a null at each step when applying zero or +2.5 volts at point A.

i. Vary the voltage at point A from +2.5 volts to zero, then to -2.5 volts. Note the maximum change on the differential voltmeter.

j. Using the voltage figures obtained in step "h", calculate the linearity (in % of full scale) output using the following equation:

$$\text{Linearity } (\%) = \frac{\text{Max. Voltage Diff. (between A \& B)} \times 100}{\text{Full scale output voltage (2.5 volts)}}$$

A voltage difference between A and B of 5 mv or less gives .2% linearity or better.

3. Common-Mode Rejection

a. Connect the amplifier as shown in Figure 6-3. Use an H-P 200 CD oscillator or equivalent for the common-mode generator. Use an oscilloscope capable of measuring 10 millivolts. R1 and R2 are 0-350 Ω resistors.

b. See Initial Preparations (paragraph 6-6, B).

c. Set the oscillator output to a voltage within the common-mode voltage specifications (0-20 volts P-P).

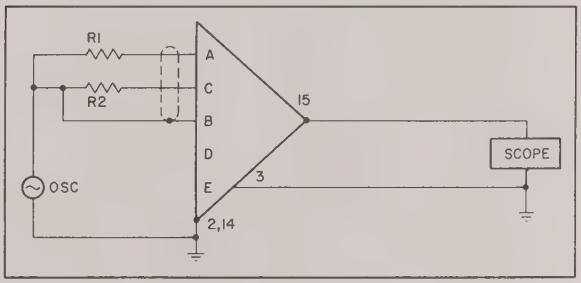


Figure 6-3. Common-Mode Rejection Test Circuit

d. Measure the peak-to-peak value of common-mode voltage at the amplifiers output $(E_o)_{cm}$.

e. Calculate common-mode rejection (in db) using the following equation:

$$\text{CMR (db)} = 20 \log \frac{E_{in}}{E_o}_{cm} \times G$$

where: $\frac{E_{in}}{E_o}_{cm} = \frac{\text{CM voltage input (P-P)}}{\text{CM voltage output (P-P)}}$

G = Amplifier gain setting

f. To measure d-c common-mode rejection, replace the oscillator with a d-c power supply. Measure the common-mode voltage at the output with a differential voltmeter.

1) Connect the d-c power supply and differential voltmeter to the amplifier.

2) With d-c power supply connect a jumper across output of the power supply to assure that no voltage is present. Measure the d-c voltage at the output of the amplifier. If more than 100 millivolts is present, adjust the OUTPUT ZERO control.

3) Remove jumper from power supply, and apply and adjust the power supply to the desired level of common-mode voltage. Note the change in amplifier d-c voltage from the value noted in step 2).

4) Calculate CMR using equation in step "e". Note that the "common-mode voltage output" is only the change in amplifier output observed upon application of the d-c common-mode voltage.

4. Noise

a. Connect the amplifier as shown in Figure 6-4. R1 is a wirewound or metal film resistor from 0-1000 ohms. Resistor R4 and C1 are a 10KHz filter; R1 is 1500 ohms, and C1 is .01 μfd.

b. See Initial Preparations (paragraph 6-6, B).

c. Measure the rms output noise with the H-P 3400A True RMS Voltmeter.

d. Remove the 10KHz filter (R4 and C1) and repeat step "c" over the whole amplifier bandwidth.

NOTE

Be sure that R1 is well shielded from stray fields.

5. Output Impedance

a. Connect the amplifier as shown in Figure 6-5. Select R1 to provide the amplifier output, specified below. R_L is a 20 ohm resistor.

b. See Initial Preparations (paragraph 6-6, B).

c. Connect a d-c differential voltmeter to the output, and a d-c power supply to the input, as shown.

d. With no load on the amplifier (S1 open) adjust the d-c power supply until the amplifier output voltage is 1.3 volts d-c.

e. Close S1, placing R_L across the amplifier output, and observe the change in amplifier output voltage on the differential voltmeter.

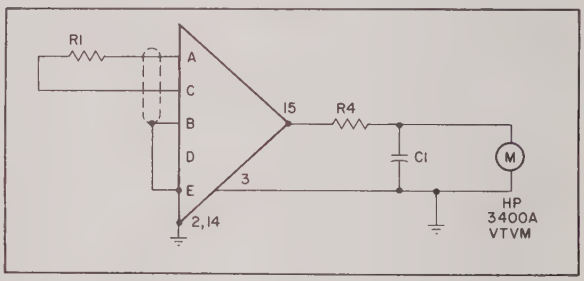


Figure 6-4. Noise Test Circuit

f. Calculate output resistance, R_o, using the following equation:

$$R_o = \frac{\Delta E_o}{\Delta I_o} = \frac{(\text{Change in } E_o) \times R_L}{E_o \text{ (loaded)}}$$

g. To measure output impedance at frequencies up to 10KHz, replace the d-c power supply with an H-P 400H VTVM.

h. Repeat steps b and d, except adjust the output to 920 millivolts rms (1.3 volts peak).

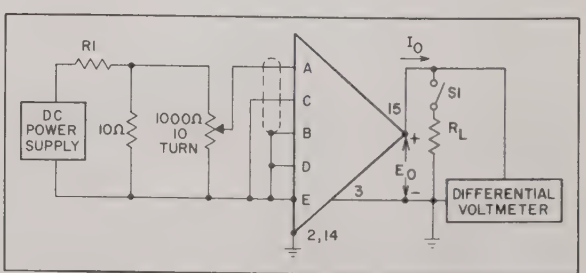


Figure 6-5. Output Impedance Test Circuit

i. Repeat step e.

j. Calculate output impedance, Z_o, using the following equation:

$$Z_o = \frac{E_o}{I_o} = \frac{(\text{Change in } E_o) \times R_L}{E_o \text{ (loaded)}}$$

6. Gain Accuracy

a. Connect the amplifier as shown in Figure 6-6. Use R2 = 10Ω ±.01%. The value of R1 is given by:

R1 = R2 (G-1), ±.01%,

where G is the gain of the amplifier.

R1 and R2 attenuate by a factor equal to the reciprocal of the theoretical amplifier gain.

b. See Initial Preparations (paragraph 6-6, B).

c. Rotate the vernier gain control to the fully CCW position.

d. With switch S1 in the 1 position, zero the amplifier output with the OUTPUT ZERO control. If the output cannot be exactly zeroed, due to the resolution of the control, record the residual voltage.

e. Switch S1 to position 2, and adjust the power supply voltage to approximately 2.5 volts with a d-c voltmeter (not shown).

f. Note the change in reading of the differential voltmeter. A change of less than ±12.5 millivolts indicates an amplifier gain accuracy of ±.5% or better.

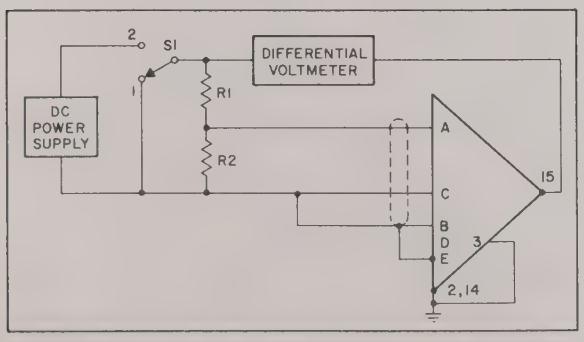


Figure 6-6. Gain Accuracy Test Circuit

6-7. CALIBRATION

A. Perform calibration of the Accudata 120 during periodic maintenance or subsequent to any corrective maintenance. Adjustments are located on the printed circuit card.

1. Coarse Zero

a. Connect the amplifier as shown in Figure 6-7.

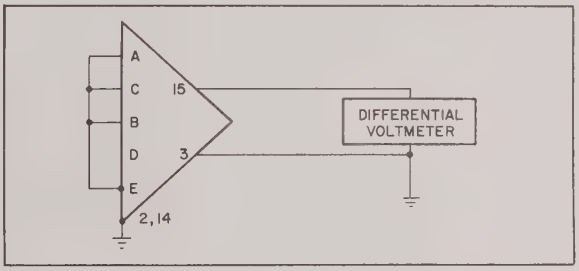


Figure 6-7. Coarse Zero Adjustment Circuit

b. Set the GAIN RANGE switch to the 1000 position, and the GAIN switch to 1000.

c. Adjust trimpot R5 until the d-c output of the amplifier is zero ±10 millivolts. Note: If Q1 has been changed, the polarity of its V_{be} match may be opposite to that of the original transistor pair. In this case R5 will not adjust the output to zero without changing R4. If R4 is a 20 ohm resistor, replace with a jumper, and vice-versa. If the setting of R5 falls near the minimum resistance end and resolution is inadequate, change R4 to 10Ω.

d. Switch the GAIN RANGE control to the 100 position, and adjust the OUTPUT ZERO control until the output is again zero ±10 millivolts.

e. Switch the GAIN RANGE control to the 1000 position and again adjust R5.

f. Repeat steps "d" and "e" until the change in output voltage is less than ±10 millivolts when the GAIN RANGE control is switched.

2. Common-Mode Rejection - Balanced Source

a. Connect the amplifier as shown in Figure 6-3. Set R1 and R2 = 0.

b. Set the GAIN switch to 1000.

c. Adjust the test oscillator to 20 volts p-p at 60 Hz.

d. Adjust trimpot R9 until the common-mode voltage appearing at the amplifier output is minimized.

e. Switch the GAIN RANGE switch to the 100 position.

f. Repeat step "d" with trimpot R10.

3. Input Current

a. Connect the amplifier as shown in Figure 6-8 with Rp = 1000 Ω.

b. Set the GAIN RANGE switch to the 1000 position, and the GAIN switch to 1000.

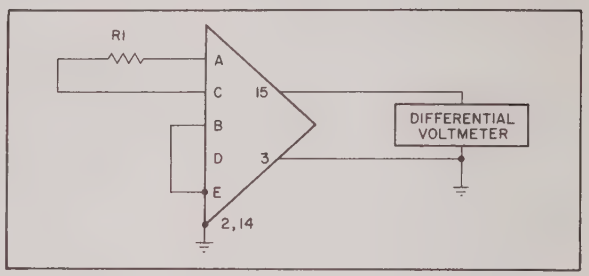


Figure 6-8. Input Current Adjustment Circuit

c. Adjust the OUTPUT ZERO control until the output is zero ±10 millivolts.

d. Connect a jumper between one side of R1 and ground. Adjust trimpot (single turn) R67 until the output voltage is again zero ±10 millivolts.

SECTION VII — PARTS LIST

7-1. GENERAL

This section lists all unit electrical parts by assembly sequence, in alphameric order. Parts of a particular assembly are indented and listed directly below the assembly listing. The following explains the column headings used in the parts list.

A. SCHEMATIC REFERENCE. This column lists the schematic reference designations of electrical components in alphameric order. Refer to paragraph 7-2 for a listing of reference designators.

B. DESCRIPTION. This column lists the component name and specifications as required for proper identification.

C. MANUFACTURER'S CODE AND PART NUMBER. These column list the manufacturer's Federal Supply Code as described in the Federal Supply Code for Manufacturer's (Cataloging Handbook H4-2) and manufacturer's part number for all parts that may be ordered directly from the original manufacturer. In some cases, other manufacturers can supply an "or equal" part; but the intent is to show only one outside source.

D. HONEYWELL PART NUMBER. This column lists the number by which an item or assembly may be ordered directly from Honeywell-Test Instruments Division.

E. QUANTITY PER UNIT. This column reflects the total quantity of each item used in that assembly.

7-2. REFERENCE DESIGNATORS

The following lists the abbreviations used with schematic reference designators:

A	- amplifier or assembly	M	- meter
B	- motor	MP	- mechanical part
C	- capacitor	P	- part
CR	- diode	Q	- transistor
DS	- device signaling (lamp)	R	- resistor
		RT	- thermistor
E	- misc electronic part	S	- switch
F	- fuse	T	- transformer
FL	- filter	TP	- test point
J	- jack	V	- vacuum tube, neon bulb, photocell, etc.
K	- relay		
L	- inductor	VR	- zener diode

7-3. ABBREVIATIONS

The following abbreviations are used in the "Description" column of the parts list:

A	= amperes
AFC	= automatic frequency control
AMP	= amplifier
BFO	= beat frequency oscillator
BP	= bandpass
CER	= ceramic
CMO	= cabinet mount only
COEF	= coefficient
COM	= common
COMP	= composition
CONN	= connector
CRT	= cathode-ray tube
DEPC	= deposited carbon
DIE	= dielectric
ELECT	= electrolytic
ENCAP	= encapsulated
F	= farads
FXD	= fixed
GE	= germanium
GL	= glass
GND	= ground(ed)
H	= henries
HR	= hour(s)
IMPG	= impregnated
INCD	= incandescent
INS	= insulation(ed)
K	= kilo = 1000
LIN	= linear taper
LOG	= logarithmic taper
LPF	= low pass filter
MEG	= meg = 10^{6}
M	= milli = 10^{-3}
MINAT	= miniature
METFLM	= metal film
MFR	= manufacturer
MOM	= momentary
MTG	= mounting
MY	= mylar
NC	= normally closed
NE	= neon
NO	= normally open
NPO	= negative positive zero (zero temperature coefficient)
P	= peak
PC	= printed circuit board
PF	= picofarads = 10^{-12} farads
P-P	= peak-to-peak
PIV	= peak inverse voltage
POR	= porcelain
POS	= position(s)
POLY	= polystyrene
POT	= potentiometer
RECT	= rectifier
RF	= radio frequency
RMS	= root-mean-square
RMO	= rack mount only
S-B	= slow-blow
SE	= selenium
SEMICON	= semiconductor
SI	= silicon
SIL	= silver
SP	= special
TA	= tantalum
TD	= time delay
TI	= titanium
TOG	= toggle
TOL	= tolerance
TRIM	= trimmer
U	= micro = 10^{-6}
V	= volts
VAC	= vacuum
VAR	= variable
W/	= with
W	= watts
WW	= wirewound
W/O	= without

7-4. MANUFACTURERS

The manufacturer's Federal Supply Code appears in the parts list. Following is a list of the codes used with the corresponding manufacturer's name and location.

CODE	MANUFACTURER
01295	Texas Instrument - Semiconductor Div. Dallas, Texas
02660	Amphenol - Borg Electronics Maywood, Illinois
03508	General Electric - Semiconductor Prod. Syracuse, N. Y.
03877	Transitron Electronics Corp. Wakefield, Mass.
04713	Motorola - Semiconductor Products Div. Phoenix, Arizona
07716	International Resistance Corp. Burlington, Iowa
11352	Transformer Electronics Boulder, Colorado
12463	Omtronics Mfg. Co. Omaha, Nebraska
12697	Clarostat Mfg. Co., Inc. Dover, N. H.
13715	Fairchild Semiconductor San Rafael, California
14655	Cornell-Dubilier Electric Corp. Newark, New Jersey
18041	Power Components Inc. Scottsdale, Pa.
18725	RCA, Semiconductor Div. Somerville, New Jersey
44655	Ohmite Mfg., Company Skokie, Illinois
56289	Sprague Electric Company North Adams, Mass.
71450	Chicago Telephone Supply Elkhart, Indiana
71785	Cinch Mfg. Company Chicago, Illinois
72699	General Instruments Newark, New Jersey
73445	Amperex Hicksville LI, N. Y.
96791	Amphenol Control Division Amphenol-Borg Electronic Corp. Janesville, Wisconsin

7-5. PARTS LIST

See the following pages. Refer to Figures 7-1, 7-2, and 7-3 for parts location.

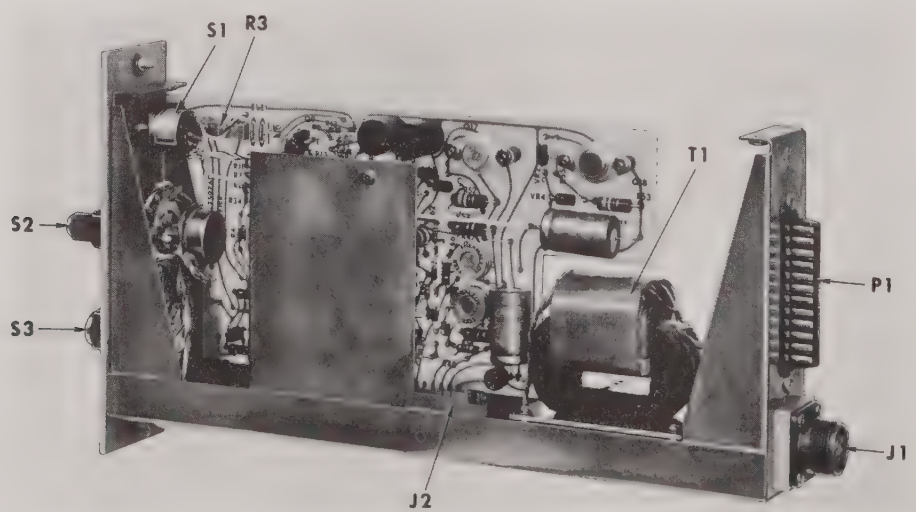


Figure 7-1. Chassis Parts Location

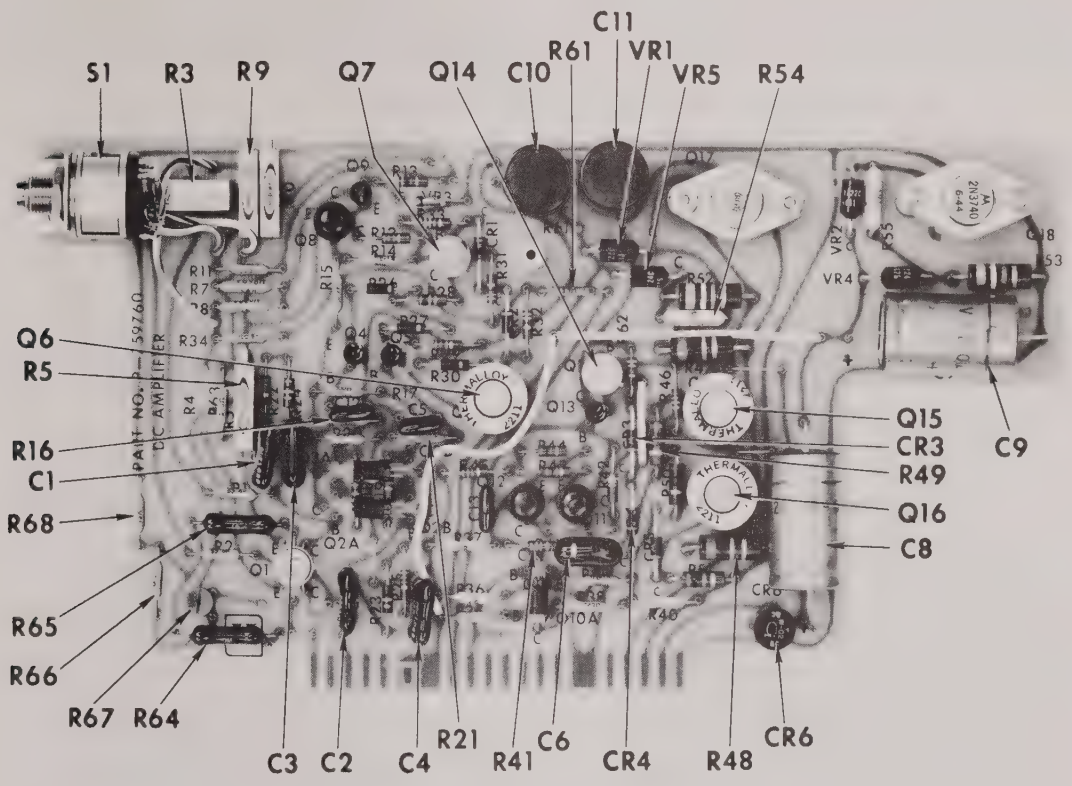


Figure 7-2. Circuit Card, Parts Location

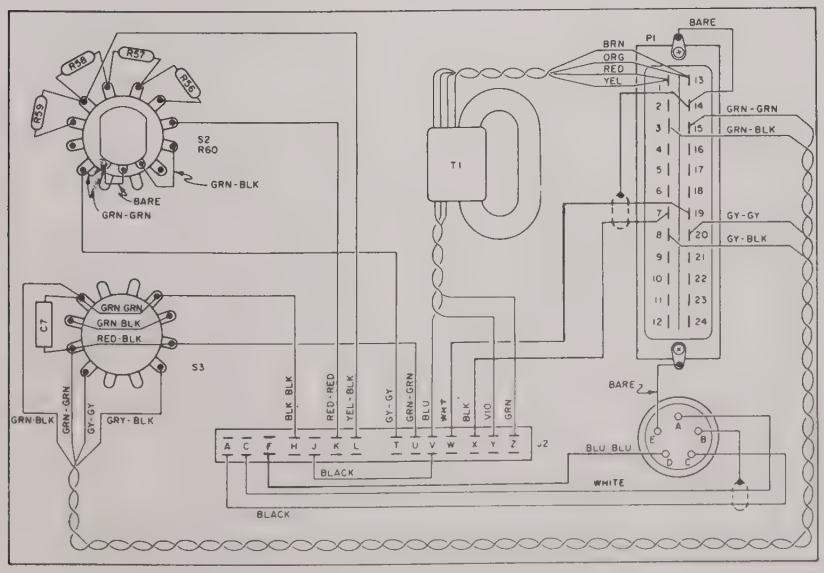
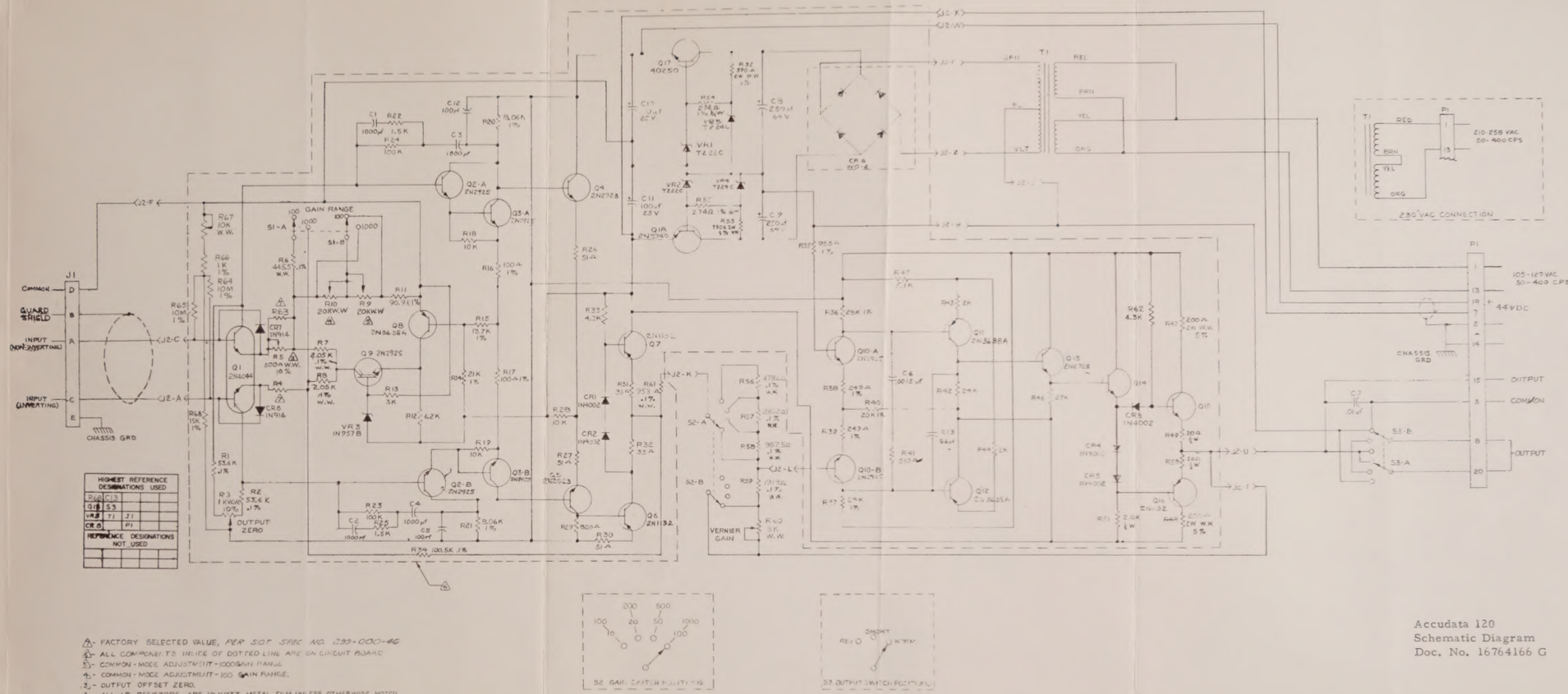


Figure 7-3. Accudata 120 Wiring Diagram

References			Description	Manufacturer's		Honeywell Part No.	Qty/ Assy	Spares
Fig	Index	Schem		Code	Part Number			
			AMPLIFIER ASSY. - ACCUDATA 120					
			Final Assy, 115 VAC			16764161-001		
			Final Assy, 230 VAC			16764161-002		
			Chassis Assy			16759661-001		
			Circuit Card Assy			16759760-005		
7-2		C1-C4	C, Fxd, Mica, 1000 pf, 500 V	14655	Type CD19	16759782-262	4	
		C5	C, Fxd, Mica, 100 pf, 500 V	14655	Type CD15	16759781-256	2	
		C6	C, Fxd, My, 0.0015 μf, 600 V, 10%	14655	DPMS-6D15	16756580-008	1	
		C7, C8	C, Fxd, 250 μf. 64 V	73445	C437 AR H250	16758518-364	2	
		C9	Not assigned					
		C10, C11	C, Fxd, Elect Alum, 100 μf, 25 V	56289	89D226	16750030-013	2	
		C12	Same as C5					
		C13	C, Fxd, Mica, 56 pf, 500 V	14655	Type CD15	16759781-251	1	
		CR1-CR5	Semicon Device, Diode	04713	1N4002	16756961-002	5	
		CR6	Semicon Device, Diode	72699	WO-2	16759755-002	1	
		CR7	Semicon Device, Diode, Si	01295	1N914	16756865-001	1	
		Q1	Transistor		2N4044	16763095-003	1	
		Q2, Q3	Transistor, Matched Pair			16756917-001	2	
		Q4, Q5	Transistor, Sil, NPN	03508	2N2923	16758481-004	3	
		Q6, Q7	Transistor, Sil, PNP	03877	2N1132	16762214-001	3	
		Q8	Transistor, Sil, PNP	13715	2N3638A	16762888-001	3	
		Q9	Transistor, Sil, PNP	03508	2N2925	16758481-006	1	
		Q10	Transistor, Assembly			16756917-002	1	
		Q11, Q12	Same as Q8					
		Q13	Same as Q4					
		Q14, Q15	Transistor, Sil, NPN	13715		16307537-001	2	
		Q16	Same as Q6					
		Q17	Transistor, Sil, NPN	18725	40250	16762501-001	1	
		Q18	Transistor, Ge, PNP	01295	2N3740	16763116-001	1	
		R1, R2	R,Fxd, Metflm, 53.6 K, ±1%, 1/8 W	07716		16757165-371	2	
		R3	R, Var, WW, 1 K, ±10%, 1/8 W	80294	275-1202	16750052-333	1	
		R4	Factory Selected Value				1	
		R5	R, Var, WW, 100Ω, ±10%, 1 W	96791	Series 2600	16757711-003	1	
		R6	R, Fxd, WW, 4455Ω, 1%, 1 W	12463	Type T1A	16759694-018	1	
		R7, R8	R, Fxd, WW, 2.05 K, ±0.1%, 1W	12463	Type T1A	16759694-006	2	
		R9, R10	R, Var, WW, 20 K, ±10%, 1 W	96791	Series 2600	16757711-006	2	
		R11	R, Fxd, Metflm, 90.9 K, ±1%, 1/8W	07716		16757165-393	1	
		R12	R, Fxd, Carbon, 6.2K, ±5%, 1/4 W	44655	LIDED-6.2 K	16750076-052	1	
		R13	R, Fxd, Carbon, 3 K, ±5%, 1/4 W	44655	LIDED-3K	16750076-044	1	
		R14	R, Fxd, Metflm, 21 K, ±1%, 1/8 W	07716		16757165-332	1	
		R15	R, Fxd, Metflm, 13.7 K, ±1%, 1/8 W	07716		16757165-314	1	
		R16, R17	R, Fxd, Metflm, 100Ω, ±1%, 1/8 W	07716		16757165-101	2	
		R18, R19	R, Fxd, Carbon, 10 K, ±5%, 1/4 W	44655	LIDED-10 K	16750079-057	3	
		R20, R21	R, Fxd, Metflm, 8.06 K, ±1%, 1/8 W	07716		16757165-288	2	
		R22	R, Fxd, Carbon, 1.5 K, ±5%, 1/4 W	44655	LIDED-1.5 K	16750079-037	2	
		R23, R24	R, Fxd, Carbon, 100 K, ±5%, 1/4 W	44655	LIDED-100 K	16750079-081	2	
7-2		R25	Same as R22					

References			Description	Manufacturer's		Honeywell Part No.	Qty/ Assy	Spares
Fig	Index	Schem		Code	Part Number			
7-2		R26, R27	R, Fxd, Carbon, 51Ω, ±5%, 1/4 W	44655	LIDED-51	16750079-002	3	
		R28	Same as R18					
		R29	R, Fxd, Carbon, 820Ω, ±5%, 1/4 W	44655	LIDED-820	16750079-031	1	
		R30	Same as R26					
		R31, R32	R, Fxd, Carbon, 33Ω, ±5%, 1/4 W	44655	LIDED-33	16750079-144	2	
		R33	R, Fxd, Carbon, 4.3 K, ±5%, 1/4 W	44655	LIDED-4.3 K	16750079-048	2	
		R34	R, Fxd, Metflm, 100.5 K, ±0.1%, 1/8 W	07716		16759698-970	1	
		R35	R, Fxd, Metflm, 953Ω, ±1%, 1/8 W	07716		16757165-195	1	
		R36, R37	R, Fxd, Metflm, 28 K, ±1%, 1/8 W	07716		16757165-344	2	
		R38, R39	R, Fxd, Metflm, 249Ω, ±1%, 1/8 W	07716		16757165-139	2	
		R40	R, Fxd, Metflm, 20 K, ±1%, 1/8 W	07716		16757165-330	1	
		R41	R, Fxd, Carbon, 510Ω, ±5%, 1/4 W	44655	LIDED-519	16750079-026	1	
		R42	R, Fxd, Carbon, 24 K, ±5%, 1/4 W	44655	LIDED-24 K	16750079-066	1	
		R43, R44	R, Fxd, Carbon, 2 K, ±5%, 1/4 W	44655	LIDED-2 K	16750079-040	2	
		R45	R, Fxd, Carbon, 5.1 K, ±5%, 1/4 W	44655	LIDED-5.1 K	16750079-050	1	
		R46	R, Fxd, Carbon, 27 K, ±5%, 1/4 W	44655	LIDED-27 K	16750079-067	1	
		R47, R48	R, Fxd, WW, 200Ω, ±5%, 2 W	07716		16756611-003	2	
		R49, R50	R, Fxd, Carbon, 20Ω, ±5%, 1/2 W	44655	LIDFA-20	16750076-508	2	
		R51	R, Fxd, Carbon, 2 K, ±5%, 1/2 W	44655	LIDFA-2 K	16750076-557	1	
		R52, R53	R, Fxd, WW, 390Ω, ±5%, 2 W	07716		16756611-044	2	
		R54, R55	R, Fxd, Metflm, 274Ω, ±1%, 1/4 W	07716		16757161-143	2	
		R56, R60	See Switch Assy, Gain					
		R61	R, WW, 953Ω, .1%, 1 W	12463	Type T1A	16759694-004	1	
		R62	Same as R33					
		R63	R, Fxd, 21.5Ω, ±1%, 1/8 W	07716		16757165-033	1	
		R64, R65	R, Fxd, 10 M, ±1%			16750068-002	2	
		R66	R, Fxd, 1 K, ±1%, 1/8 W	07716		16757165-201	1	
		R67	R, Var, 10 K, 10%			16755293-005	1	
		R68	R, Fxd, 15 K, ±1%, 1/8 W	07716		16757165-318	1	
		R69	Same as R65					
		S1	Switch, Rotary, 2P2P	12697	CM32861	16759696-001	1	
		VR1, VR2	Semicon Device, Diode, Zener, 22 V, ±1%	18041	TZ22C	16759870-016	2	
		VR3	Semicon Device, Diode, Zener, 6.8 V, ±5%	04713	1N957B	16756688-107	1	
7-2		VR4, VR5	Semicon Device, Diode, Zener, 24 V, ±1%	18041	TZ24C	16759870-017	2	
7-1		J1	Connector	02660	AN3102A-14S-5S	16100058-001	1	
			Cable and Component Assy			16764162-001	1	
7-3			Switch Assy, Output			16759818-001	1	
		C7	C, Fxd, My, 0.01 μf, 200 V	56289	192P10392	16750035-002	1	
		S3	Switch, Rotary, 2P3P	71450	54035	16759697-001	1	
7-3			Switch Assy, Gain			16764163-001	1	
			R, Fxd, WW, 4786Ω, ±0.1%, 1 W	12463	Type T1A	16759694-002	1	
			R, Fxd, WW, 2872Ω, ±0.1%, 1 W	12463	Type T1A	16759694-021	1	
			R, Fxd, WW, 9575Ω, ±0.1%, 1 W	12463	Type T1A	16759694-020	1	
			R, Fxd, WW, 1918Ω, ±0.1%, 1 W	12463	Type T1A	16759694-019	1	

References			Description	Manufacturer's		Honeywell Part No.	Qty/ Assy	Spares
Fig	Index	Schem		Code	Part Number			
7-1		R60/S2	Switch, Var Res, 2P4P, 3000Ω	71450	56226	16759692-002	1	
7-3		J2	Connector, Card			16200578-001	1	
7-1		P1	Connector Plug	71758	36-4100-24P	16100790-001	1	
7-1		T1	Transformer, Power	11352		16759765-002	1	



△1- FACTORY SELECTED VALUE, PER SOT SPEC NO. 1299-000-46
△2- ALL COMPONENTS INSIDE OF DOTTED LINE ARE ON CIRCUIT BOARD
△3- COMMON-MODE ADJUSTMENT-1000 GAIN RANGE
△4- COMMON-MODE ADJUSTMENT-100 GAIN RANGE.
△5- OUTPUT OFFSET ZERO.
2 - ALL 1% RESISTORS ARE ¼ WATT METAL FILM UNLESS OTHERWISE NOTED.
1 - ALL RESISTORS ARE ¼ WATT, 5% CARBON COMPOSITION UNLESS OTHERWISE NOTED.

Accudata 120
Schematic Diagram
Doc. No. 16764166 G

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